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BUREAU OF ENTOMOLOGY AND PLANT QUARANTINE

FOREST INSECT INVESTIGATIONS

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SUMMARY OF INSECT SURVEYS AND CONTROL - 1908-1945

SEQUOIA NATIONAL FOREST, CALIFORNIA

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FOREST INSECT LABORATORY
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J. M. Miller
- Entomologist -

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341 Giannini Hall, U. C.
Berkeley 4, California
December 21, 1945

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SEQUOIA NATIONAL FOREST, CALIFORNIA

- - -

J. M. Miller

Over the past three or more decades, forest insect infestations have occurred on various portions of the Sequoia National Forest with varying degrees of intensity. The history of such outbreaks as have occurred since 1908 and what was done about them can be found scattered through reports, correspondence and memoranda which have accumulated in the files of the Forest Service and Forest Insect Laboratory. It is the purpose of this report to review these records in order to bring into historical perspective the more important entomological events that have effected this particular Forest. Under the assumption that history usually repeats itself, the story of what has occurred in past years may have value as an indicator of what is to be expected in years to come.

The continuity of the Sequoia records has suffered a number of interruptions, due in part to the lack of any surveys or reports for certain years; and also to several major changes which have been made in the areas included within the Forest boundaries. The eastern part of the Sequoia was administered as the Kern National Forest up to July 1, 1914; and in recent years a fairly large elimination of area has resulted through transfer to the Kings Canyon National Park.

I. CHRONOLOGICAL SUMMARY.

It is possible to break down an account of forest insect activities in several different ways in order to give homogenous grouping to the subject matter. It would be possible for example to take up each important insect species and trace its history by years and areas. Or, it would be possible to select specific areas or forest types and treat the infestations that have developed in them in connected sequence. However in view of the limited records that are available for the Sequoia it seems best first to list by years the developments that have taken place over the Forest as a whole. In this way we can bring together what is known about insect infestations of the past in their natural sequence. Beginning with the first record in 1908 the story can be carried down to the current year of 1945.

1908

The first mention of dying timber on the Sequoia is found in old correspondence. A record in the files of the Forest Insect Laboratory at Berkeley states that Forest Assistant Maude reported affected and dying Jeffrey pine in the Little Kern River area. That this was thought to be caused by a disease is indicated by the record of the following year.

1909

Handed down from this year is a letter from A. D. Hopkins (1), in charge of Forest Insect Investigations for the Bureau of Entomology to S. T. Dana of the Branch of Silviculture of the Forest Service at Washington, D. C. Apparently Dana had collected specimens of pine foliage, probably in the area reported by Maude the previous year, and transmitted them to the Bureau of Plant Industry. Hopkins' letter is of considerable entomological interest and is quoted in its entirety:

"

September 1, 1909

Mr. S. T. Dana
Branch of Silviculture
Forest Service
Washington, D. C.

Dear Sir:

Returning to my office after an absence of several weeks, I find reference to a communication through Dr. Metcalf, of the Bureau of Plant Industry, relative to specimens of yellow pine collected by you in the Sequoia National Forest, California, and submitted to the Forest Pathologist.

These were referred to the Bureau of Entomology and were found to show work characteristic of one of the so-called needleminers. As a rule, these insects do no damage to the tree, even when they are very abundant, because they affect only the tip of the needles, the base remaining green. Some years ago we had a report coming from Prof. Comstock, of Cornell University, that the forests of lodgepole pine looked brown from the work of this insect, but subsequent investigation showed that the brown condition of the timber was probably due to the work of Dendroctonus monticolae. Then again, the dying tips of the needles, as a result of abnormal climatic conditions, is often mistaken for the work of this insect. Therefore, it is not safe to base conclusions on information received from the casual observer.

Such matters should be looked into very carefully to see whether or not the majority of needles are killed by the leaf miner, by climatic conditions, or as a result of attacks by destructive bark beetles. It is evident that if the trees are really dying that the trouble is caused by bark beetles.

We should be glad to have information as to the extent of the dying timber and to have specimens of bark and wood from the trunks of those which seem to be freshly attacked as indicated by pitch tubes, etc.

Very truly yours,

/s/ A. D. Hopkins
In Charge, Forest Insect Investigations"

Another record for this year is found in a report by Ranger Ralph Hopping (2) on forest insect conditions in Ranger District 10 (Dunlap). Hopping stated: "No where in my district has any body of timber been attacked by insects. The depredations seem to be confined to trees here and there distributed through the whole forest." Hopping recommended that when slash is burned, the limbs and smaller material should be burned on top of the logs in order to destroy bark beetle broods under the bark.

1910

Conditions on the Sequoia received considerable attention this year through an investigation of the diseases of forest trees by Dr. E. P. Meinecke of the Bureau of Plant Industry, and a survey of forest insect conditions by Ranger J. M. Miller who was detailed to this study under instructions of the District Forester in San Francisco. Both of these men went into the Little Kern area to follow up the reports of dying Jeffrey pines.

During the period from June 2 to July 13, Miller made a pack trip from Hot Springs to the northern boundary of the Forest at Kings River, traversing mainly pine areas in the Kern basin and the commercial pine forests along the western front of the Forest. The following areas were called to the attention of the Forest Supervisor in Miller's report of July 29, 1910 (3).

1. Hot Springs. A group killing of ponderosa pines, including from 200-300 recently killed trees, was found near the Hot Springs sawmill. The attack in this group appears to have been initiated by Ips topkilling, followed by the western pine beetle.

2. Capanero Creek. Killing of large mature ponderosa pine by the western pine beetle was found near Betty Waller Ranger Station. This consisted of small group attacks over a limited area. One group of seven trees was estimated to contain a volume of 21,000 board feet. Salvage of the infested trees was recommended for this and the Capanero Creek area.

3. Little Kern Area. Needleminer infestation was found to be prevalent in Jeffrey pine over about 30,000 acres, centering around Burnt Corral Meadow. About 75 percent of the stand was estimated to be noticeably affected by the defoliation, 25 percent was seriously weakened, and 10 percent was either dead or dying. The Jeffrey pine beetle was found to be concentrating in the more heavily defoliated stands and was considered to be an important factor in bringing about death of the trees. It was estimated that about 40 million board feet of timber in this area was either dead or dying and should be salvaged. Because of the inaccessibility of this timber and lack of knowledge of the biology of the insects involved, no control recommendations were made.

4. Millwood Area. Trees killed by the western pine beetle were found in small isolated groups throughout the lower yellow pine belt.

5. Moraine Meadows (Roaring River). About 3 to 5 percent of the lodgepole pine stand had been attacked and killed by the mountain pine beetle.

1911

Kern River Area. A report which was submitted in 1915 by Forest Supervisor Lyons (9) states that in September 1911 S. W. Wynne established a plot in the Little Kern basin to study survival of Jeffrey pine infested by the needleminer. Presumably this was located at Grey Meadow, but the original data as to number, location and condition of trees are lacking.

1912

Conditions for this season were reported from six ranger districts in accordance with instructions from the District Forester calling for an annual report each year from the field. All reported small infestations of bark beetles which apparently were not considered to be very serious. The more important infestation seemed to be in the Kern National Forest where Roscoe Parkinson reported a D. monticolae infestation in lodgepole pine. He reported counting 200 infested trees on an area of 30 acres. Ranger W. F. Derby (4) gave a description of the needleminer infestation:

> "Jeffrey pines in Freeman Valley and the Little Kern basin are attacked by a microlepidoptera larva which works in the needles, which has not been identified as far as I know, and is probably the primary enemy. The characteristic workings of at least two species of Dendroctonus are noticeable on trees which have died during the past three years, but I believe such attacks are secondary. The trees attacked by the needleminer have a characteristic washed-out look and only such trees show the work of Dendroctonus."

1913

This year Ralph Hopping (5) on special detail as Forest Examiner made a survey of both the Sequoia and Kern National Forests and reported separately for each forest. He visited all of the areas that had been reported by the District Rangers in 1912 and summarized the bark beetle situation as follows:

> "Epidemic infestations exist at Lloyd Meadows, Little Kern and in Kings Canyon and vicinity. Local infestations above the normal exist at Nelson's Camp, Camp Wishon, Redwood Meadow, Big Meadow, Runkel's Meadow, Huckleberry Meadow and the headwaters of Dry Creek."

On the needleminer situation in the Little Kern area, Hopping made the following comment:

"Needleminer was reported as killing the Jeffrey pine in the Little Kern and Lloyd Meadow. As a matter of fact the needleminer is not killing and has not killed the trees in the Little Kern Valley. Dendroctonus and Melanophila work in Lloyd Meadow has been mistaken for needleminer. The needleminer is not in the Lloyd area.

"About 60 percent of the trees in the Little Kern are badly infested with needleminer and appeared to be in a dying conditions. These trees, however, have resisted the attacks for years."

In November of 1913 the first bark beetle control project was initiated on the Sequoia. According to a report by Ranger Robert R. Martin (6) two rangers on the Greenhorn District worked for two days on contributed time treating a group of 35 infested ponderosa pines near the Ranger Station. The trees were cut and burned. The following data were included in the report:

"Area	960 acres
Timber stand	4,700 MBM
Value at $2. per M	$9,400.
Cost of protection	$15.32
Number of trees treated	35 yellow pines
Average DBH (Max. 30", Min.3")	13. inches
Average volume	140 board feet
Number man-days expended	4 "

1914

In August of this year, Ralph Hopping (7) reported a striking increase in bark beetle infestation at the head of Dry Creek. In an area where he had noted 60 trees in 1913, he found 400 trees in 1914.

Forest Supervisor Frank Cunningham (8) reported on conditions for the entire Forest and in a letter to the Regional Forester proposed a comprehensive control program. Attached to this letter was a map of the Mill Creek and McKenzie Ridge areas showing location of infested trees. For the entire Forest, Cunningham estimated a total of 5,943 trees to be treated in eight designated areas, and he requested an allotment of $18,107.50 for control work. The files do not show what action was taken on Cunningham's recommendations.

1915

Acting Forest Supervisor Lyons (9) made an examination of the needleminer plot in the Little Kern basin in September of this year. This covered an interval of four years since the plot was established by Wynne in 1911. Lyons was able to identify but 40 trees which had been numbered and recorded by Wynne, none of which had died during the interval.

	No. trees	Percent
Trees recovered	2	5.
Trees partly recovered	18	45.
Trees showing no change	17	42.5
Trees showing worse condition	3	7.5
	40	100.

Lyons concluded that the needleminer had been at work for many years and that the trees do not immediately succumb but recover for a time. He recommended that the study be continued and another follow-up examination made in 1918, but there is no record of this having been carried out. Lack of subsequent reports would indicate that there was a general subsidence of the needleminer following the 1908-15 period and because of the inaccessibility of the area the study was discontinued.

1916

There are no records of surveys or insect control reports for this year. Ralph Hopping (10) submitted a report, however, on "Primary and Secondary Borers" in which he attributed the widespread killing of pine reproduction in Mill Creek Flat during the seasons of 1910-11 to Ips confusus. He advanced the theory that this was the result of unburned slash left from clear cutting and logging operations during the 1909 season.

1917

During the summer of this year a comprehensive survey was made on the Sequoia as part of a general forest insect survey of the southern Sierra pine areas. This was a cooperative project initiated at the request of private timber owning agencies and was carried out cooperatively by the Forest Service and the Bureau of Entomology. The personnel engaged on field work were Ralph Hopping of the Forest Service and J. M. Miller of the Bureau of Entomology. During July and August the pine type of the Forest was covered by reconnaissance from the northern boundary of the Tule River Indian Reservation to the South Fork of Kings River, including the Sequoia National Park.

A report of the survey was prepared by A. J. Jaenicke (11). The Forest and Park areas were broken down into 19 infestation units, representing individual watershed areas without regard to ownership status. The 1917 losses in the accessible timber were estimated at 6,279,000 board feet of ponderosa pine and sugar pine. In 13 of the units the bark beetle infestation was classed as epidemic with the cost of control estimated at $31,000. Control work was recommended for the Middlefork of the Kaweah River, on an area of 24,000 acres, 75 percent of which was in the Sequoia National Park; and for an area of 9,000 acres in the South Fork Canyon of Kings River.

1918

The control work recommended in the Middlefork of the Kaweah River was carried out in March and April of this year as a joint project between the Forest Service and the Park Service under the supervision of Ralph Hopping (12). The project was summarized in his report as follows:

"1. Total area of project (about 50% timber type) 24,000 acres

2. Amount of infestation treated:

	Trees	Volume b.f.
Ponderosa pine	87	209,580
Sugar pine	45	169,000
Jeffrey pine	1	4,100
Total	133	382,690

3. Costs:

Sequoia National Park	$869.52
Sequoia National Forest	684.08
Total	$1,580.60
Average cost per tree	11.88
Average cost per MBM	4.13 "

In September 1918 Hopping (13) and Jaenicke made a survey of the South Fork of Kings River Canyon and established a check area of 1,280 acres in the floor of the Canyon. The 1918 losses in the area were estimated at 270 ponderosa and sugar pines with a volume of 356,100 b.f. Control work was recommended, but no action was taken because of the expected transfer of this area to the Park Service.

1919-1922, inclusive. No reports

1923

The annual report of the Regional Forester (Woodburny and Miller) summarizes the Forest Supervisor's reports as follows:

> "Conditions normal; infestations considerably less than for preceding few seasons."

Correspondence shows that in June of this year, Frank Cunningham (14) reported a needleminer infestation in lodgepole pine at Mineral King and sent specimens of infested needles to J. M. Miller at North Fork. Adult moths were reared from this material which were tentatively identified as Recurvaria milleri.

1924. No reports

1925

This season was one of generally increasing infestations following the severe drought year of 1924. The Annual Report (Woodbury and Miller) gives a tabulated summary of information submitted by the Forest Supervisor:

" Area	Trees/section	Species affected	Condition of infestation
Trout Creek	75	Jeffrey pine	increasing
Greenhorn Mtn.	68	Ponderosa pine, sugar pine, white fir	increasing
Breckenridge Mtn.	15	Jeffrey pine, ponderosa pine	increasing
Pine Ridge	40	Ponderosa pine	increasing
Deer Creek	21	Mixed conifer	decreasing
Mineral King	40 trees on 10 acres	Lodgepole pine	increasing (needleminer)

In general areas of infestation show a marked increase. No control work is recommended until we have a chance to observe effect of several seasons of normal infestation upon resistance of trees."

Correspondence files contain a letter from Forest Supervisor Cunningham (15) in which he reports local infestations which he considered to be serious in Lower Pierce Canyon (67 trees); Hume area (225 trees on 3 sections); and the Pinehurst area (many ponderosa pines, especially poles and saplings). These losses were composed mainly of ponderosa and sugar pines. He proposed disposing of the beetle-killed trees in the Pierce Canyon area through sale to a logging operator.

1926

The Annual Report for this season contains no reference to the Sequoia. Apparently observations on the increasing infestations reported the previous year were not followed through.

1927

Two areas were listed in the Annual Report (Woodbury and Miller) with the following comments:

> "Tule River District. Heavy loss in sugar pine; also in ponderosa pine; and incense cedar reproduction and poles.
> Cannel Meadow District. Considerable loss in Jeffrey pine stands."

1928

Annual Report (Keen and Woodbury) states:

> "General situation: Losses light, conditions have improved.
> Rattlesnake Creek: 50 ponderosa pine, 75 Jeffrey pine attacked on 320 acres; special examination requested."

1929

Annual Report (Dunston) states:

> "General condition endemic except for special areas.
> Sandy, Bear and Cedar Creeks: heavy epidemic losses in poles, saplings and seedlings of incense cedar on 1800 acres; all government.
> Camp Nelson: 35 large ponderosa pines, 50 poles on 20 acres; control recommended because of recreational value of area.
> Poison Meadow: 100 ponderosa pines on 640 acres; too inaccessible to warrant control."

1930

In February of this year Director Albright of the National Park Service reported to the Forest Service that he had noted a bad infestation the previous year in the floor of King's River canyon. This was examined by Ranger Stevenson (16) of the Pinehurst district in June, who reported:

> "On the 13th of this month Ranger Brock and I counted the dead trees from which all the needles had not fallen between the mouth of Bubbs Creek and Cedar Grove. Our count was 86 trees in the Canyon, approximately 10 of these were sugar pines and the balance ponderosa pines. Approximately one-half of these were in or near the Kings River Canyon fire area, which burned 75 acres in August 1927 and killed about 50 percent of the timber in the area."

Another examination was made of the Kings River Canyon area by J. M. Miller and Dr. F. C. Craighead in August 1930. Miller's report (17) reviewed the history of previous bark beetle surveys in this area and made an appraisal of current trends:

> "There has been a fairly sustained loss for many years of old mature trees, much of it occurring in small groups. This has resulted in many snags and a thinning of the stand on the poorer sites. In 1930 the infestation on the canyon floor was relatively low, but tributary watersheds were found to contain epidemic infestations in ponderosa pine and sugar pine. Control work to protect the pine stand on the canyon floor would have to include these tributary watersheds and would have to be continued on a maintenance basis to be effective."

Assistant Forest Supervisor Edwards in July reported that a large number of trees were dead in the Camp Nelson basin and a larger number were dying. He requested a special examination by the Bureau of Entomology. The Annual Report (Dunston) called attention to serious infestations in ponderosa and sugar pine in Camp Nelson, Kings River Canyon, Sampson Flat, Lookout Point, Good Mill, Logger Point and Stony Point.

These increasing infestation trends which were noted in the pine areas along the western front of the forest developed into spectacular epidemics as the 1930 season progressed. K. A. Salman of the Berkeley laboratory made a

special examination in December of a series of areas near Pinehurst. He found that the recent kill of ponderosa pines ran into thousands of trees in Mill Creek Canyon, Upper Milk Ranch Watershed, Sampson Flat and the Sequoia Lake basin. A sample plot, which was measured near Pinehurst, contained a 1930 loss of 240 trees per section. However, the general run of losses over the district was estimated at 180 trees per section. Salman (18) found that the usual pattern of bark beetle attack on trees killed this year consisted of an initial top-killing by Ips confusus followed later by the western pine beetle in the main bole. In analyzing the composition of this infestation, Salman stated:

> "When the large number of top-killed trees is taken into consideration and when the vigor of attack exhibited by the western pine beetle is compared with that shown by Ips confusus, there is some reason to doubt that the western pine beetle is the primary species."

On the general situation, Salman reached the following conclusions in his report:

> "In all areas the losses appear to have been heavy for at least two seasons (1929 and 1930) and epidemic conditions are evidenced by grouping of insect-killed trees. Annual losses are high and there was a marked increase of the infestation in 1930. In spite of this, it is felt that the peak of the infestation has passed."

1931

The Annual Report (Dunston) rated general conditions in the Forest for this year as epidemic or incipient epidemic in portions of the Tule River and Kings Canyon Ranger Districts. Special areas mentioned were Camp Wishon, Lookout Point, Camp Nelson and the ponderosa pine belt of the Kings Canyon District between the elevations of 3500 and 5500 feet.

A special survey was made of the Camp Nelson and Camp Wishon areas in October 1931 by G. R. Struble (19) of the Berkeley laboratory and District Ranger Snider for the purpose of control estimates. The 1931 loss in the Camp Nelson basin was determined as 413 ponderosa pines and 91 sugar pines. In the Wishon area, the loss was 172 ponderosa pines and 39 sugar pines. In addition, groups of young trees from 8 to 20 inches DBH were found to be commonly attacked.

A general report on forest insect conditions throughout the Forest was prepared by Miller (20) which called attention to other problems besides the bark beetle infestations. In discussing the trend of the Ips confusus-D. brevicomis type of infestation during 1931, Miller stated that:

> "The tendencies during the early part of the summer were shown by large groups of trees attacked by the first seasonal generation which were even larger than the groups attacked in 1930. However, there was a decline in the volume of infestation during the attack of the overwintering generation.

"Mountain pine beetle infestations in lodgepole pine were noted near Horse Corral Meadows, where on about four acres 45 percent of the lodgepole trees had been killed between the seasons of 1925 and 1931.

"The Jeffrey pine stand in the Roaring River country, mainly in the vicinity of Sugar Loaf Valley and Scaffold Meadow, was found to be in poor condition with many trees dying. This condition is characterized by a gradual die-back of the twigs and limbs until the crown becomes ragged and in some trees the crown is almost denuded of foliage. The only bark beetle infestation noted in this area was that of Dendroctonus jeffreyi. Quantitatively the amount of timber that is being killed annually is relatively light (about 40 trees per section). This loss is the result of a sustained endemic condition that has been going on without marked increase or decrease for many years.

"The needleminer infestation in lodgepole at Mineral King was found to be heavy in 1931 and although no trees had died, the effect of defoliation upon growth rate was found to be noticeable for this and previous seasons. The measurements from cores taken from selected trees indicated that severe defoliations had occurred in this area during the periods 1901-1907, 1913-1915, 1921-1926 and 1929-1932. No mountain pine beetle infestation had developed in this isolated area of lodgepole pine which apparently accounts for the survival of the defoliated trees."

1932

Guy Hopping (21) of the National Park Service made an examination of the South Fork of Kings Canyon in October to report upon the bark beetle situation for this year. He found that the infestation in the canyon floor was not aggressive at the present time, but recommended in his report that a control program be considered.

"Considering the limited stand of pines, especially the sugar pines, to be found in the narrow areas of the canyon floor it seems that steps should be taken in the immediate future to supplement the natural forces tending toward the protection of this timber from attack."

The Annual Report for 1932 (Woodbury and Dunston) states:

"This year's observations indicated a decrease of infestation on all the epidemic areas which have been mentioned in the annual reports of recent years. There appears, also, to have been a general decline of infestation throughout the Forest."

1933

The decline in intensity of bark beetle infestations which set in during the fall of 1932 had its effect upon the 1932 overwintering generations. In January 1931 District Ranger Stevenson of the Kings River District reported that he was having trouble finding infested trees. However, the

residue of infestation was sufficient to provide enough infested trees for two control projects which were carried out during the season of 1933 with relief labor.

The Sequoia Lake Basin Project was carried out during April 1933 by the State Unemployment Camp Relief located at Pinehurst. The records submitted by Ranger Wilkie Brock (22) show that 62,000 board feet were treated at a cost only for subsistence and transportation amounting to $93. Most of this infested volume was in sugar pine.

The Camp Nelson Project was carried out by the CCC camp located in this area during the summer period. Because of the time of year when this work was done, it was necessary to use the solar heat method for practically all trees. A complete report of this project was submitted by Head Spotter Don Lewis (23). This report presents a detailed analysis of the costs and difficulties involved in conducting control work during the summer period with CCC labor. The accomplishments of the project were:

Total acreage covered:		4,200
Volume of infestation treated:	Trees	Volume
Ponderosa pine	105	239,170 b.f.
Sugar pine	21	
Total	126	239,170 b.f.

Costs:	
Per trees	$9.26
Per MBM	4.90

The high costs involved in this project were attributed both to natural conditions and inexperienced labor. The unfavorable factors were that the trees were scattered and the topography steep and rough, the crews were entirely inexperienced and had to be trained, equipment was lacking in quantity and quality, and the CCC system of transportation, working hours and intermittent assignment of men slowed down the work.

1934

No reports. The Annual Report for this season does not mention Sequoia.

1935

The Annual Report (Dunston) gives the following summary:

> "Endemic infestation prevails in all parts of this Forest, except in the Camp Nelson area where on an area of 3,000 acres there are estimated to be 500 infested ponderosa and sugar pine trees. Since about one-fourth of this area is privately owned and no cooperation in control work can be secured, it is believed inadvisable to undertake such work this winter or next spring. There is a fair possibility that the privately owned lands in questions will be acquired through exchange or purchase; in which event, if epidemic conditions continue, a control project may prove advisable."

1936

A survey of the more important areas of the Sequoia was made this season by J. E. Patterson (24) of the Berkeley laboratory. For the Camp Nelson area he estimated current losses at 40 to 50 trees per section and recommended that if control were undertaken, the work be limited to the accessible parts of the area. The Annual Report of the Regional Forester (Dunston) stated:

> "Losses are uniformly low in all portions of this Forest. The only control work reported was that on and surrounding the Wishon Public Camp Ground where 38 ponderosa pines were treated with CCC labor.

1937

An examination of the Camp Nelson, Camp Wishon, Lloyd Meadows and Holby Meadows was made in August by J. E. Patterson (25) and a special report submitted. A marked reduction was found this year in the western pine beetle infestation in the Wishon and Camp Nelson areas. Patterson called attention to the deterioration of Jeffrey pine stands in the vicinity of Lloyd Meadows due to sustained infestations of the pine flathead and Jeffrey pine beetle in high risk trees. The Annual Report (Dunston) stated:

> "The favorable conditions reported last year have continued throughout the 1937 season. The control work conducted on the Wishon Public Camp Ground last year with CCC labor proved to be very effective. A few trees were treated there this season. A rather active infestation of mountain pine beetle in lodgepole pine at Holby Meadows was noted this year by J. E. Patterson. He estimates a loss of from 20 to 50 trees."

1938

A survey of the Forest was made this year by S. T. Carlson (26) of the Berkeley laboratory with a crew of three assistants. Carlson undertook to cover all of the pine areas in the western part of the Forest extending through the Kings, Kaweah and Tule River watersheds. He established sample plots at Camp Nelson, Woodward Creek and Whitaker forest on which the insect-caused losses for 1937 and 1938 were measured, including all pine species, white fir, red fir and incense cedar. Each plot was selected to represent one of four timbered units for which the following estimates were made:

"Name of Unit	Acreage	Amount of insect-caused loss - all species			
		1937		1938	
		Trees	Volume	Trees	Volume
Camp Nelson	20,000	280	381,000	240	357,000
Camp Wishon	12,000	120	83,500	107	77,000
Whitaker	30,000	990	512,400	855	408,400
Woodward Creek	14,000	600	1,903,600	280	768,000
	76,000	1990	2,880,500	1482	1,610,400
Average annual loss - all units:		37 b.f. per acre		16 b.f. per acre"	

The break down of these losses by tree species shows that for these two seasons the heaviest losses occurred in white fir and red fir, which had not been included in previous loss estimates. The pine losses, particularly in the Camp Wishon area where control had been carried on, were relatively light. The heaviest pine losses were found in Jeffrey pine in the Woodward Creek unit.

Carlson reported the lodgepole pine needleminer at Mineral King as quite active. The effects of defoliation had advanced to the point where a number of trees had dead terminals and branches. For the first time the mountain pine beetle was found in the Mineral King area where it had killed a few of the weakened trees in 1938. A severe defoliation of the Alders in the vicinity of Camp Nelson by the Alder flea beetle (Haltica bimarginata) was reported. Residents complained that the beetles entered dwelling houses and were quite annoying during the height of the flight period.

The Annual Report (Dunston) for 1938 states:

> "Low endemic losses prevail throughout this Forest. The infestation of the mountain pine beetle in lodgepole pine on the Holby Meadow area reported upon last year has disappeared."

1939

Another survey of the four unit areas established by Carlson (27) in 1938 was made in October of this year. Only the pine losses were measured this season. Carlson's report summarizes general conditions as follows:

> "Insect conditions in that part of the Forest examined are endemic. There has been a general increase of insect activity in most of the units, but this increase has not resulted in any alarming losses nor were any large centers of infestation noted. The Jeffrey pine infestation in the Woodward Creek unit appears to be the most aggressive. There has also been some increased activity of the mountain pine beetle in sugar pine in Ten Mile Creek and in the needleminer infested area at Mineral King. The total ponderosa, Jeffrey and sugar pine losses in the four units were estimated as follows:

		Annual Loss in Pines			
		1938		1939	
Name of Unit	Acreage	Trees	Volume	Trees	Volume
Camp Nelson	20,000	125	77,500	150	267,000
Camp Wishon	13,000	95	59,500	75	134,000
Whitaker	30,000		383,400	800	1,200,000
Woodward Creek	14,000	40	6,400	200	300,000
Totals	77	1,085	526,800	1,225	1,901,000

TheAnnual Report for 1939 (Dunston) states:

> "A rather aggressive infestation of the Jeffrey pine beetle was noted in stands bordering the General's Highway between General Grant and Sequoia National Parks. It is not believed of sufficient importance to warrant direct control measures at this time. Otherwise endemic conditions appear to prevail throughout the Forest."

1940

A survey of the westside pine type, covering the same unit areas as on the three preceding seasons, was made in October by Donald DeLeon (23).

> "On all but one of the plots there was an appreciable decline in the amount of infestation in pine stands over that of last year. The sugar pine infestation in the pine stands appears to have slackened slightly, but it is still in a rather high endemic condition.

		Annual Loss in Pines			
		1939		1940	
Name of Unit	Acreage	Trees	Volume	Trees	Volume
Whitaker	30,000	800	1,200,000	200	111,000
Woodward Creek	14,000	200	300,000	165	100,000
Camp Wishon	13,000	75	134,000	35	65,000
Camp Nelson	20,000	150	267,000	60	50,000 "
	97	1225	1,901	460	326

The Annual Report (Dunston) gives the following summary:

> "This year's examination by the Berkeley laboratory, as well as observations by Forest Officers, indicates that there are no outstanding loss conditions in the Forest. Jeffrey pine infestation reported last year along the General's Highway is considerably reduced. The Forest reports spotted and widespread blow-down of pine timber from a big storm in January 1941. Some flare-up of infestation may result from this severe storm."

1941

This year the plots were cruised by J. E. Patterson (29) and estimates of pine losses were made on seven watershed units, including those established by Carlson.

> "There was an appreciable decline on the better sites and a pronounced drop in pine losses throughout the marginal stands. Perhaps the greatest reduction has occurred in sugar pine infestations. That at Ten Mile Creek which was relatively high last year has almost completely disappeared. The same condition holds true in the Forest around General Grant National Park. There was a slight increase in Scolytus infestations in fir, which was generally distributed throughout these stands. Infestations in Jeffrey pine were definitely down in all stands of these species.

"

Name of Unit	Acreage	Annual Loss in Pines 1940 Trees	1940 Volume	1941 Trees	1941 Volume
Whitaker	30,000	200	111,000	120	60,000
Woodward Creek	14,000	165	100,000	90	40,000
Camp Wishon	13,000	35	65,000	20	18,000
Camp Nelson	20,000	60	50,000	30	20,000
Mineral King	10,000	30	25,000	30	25,000
Tule River	30,000	200	80,000	150	60,000
Kern River	32,000	300	150,000	200	100,000
Totals	149,000	990	581,000	640	323,000

The Annual Report (Dunston) gives the following summary for this year:

> "Low endemic infestations prevail generally. No flare-up of infestation following the severe blow-down of last year was noted. Good results in salvage of this blow-down material was secured since most of the material was taken by the Mt. Whitney Lumber Company."

1942

Due to the shortage of men for survey work under the war emergency, the Berkeley laboratory made only a reconnaissance survey of the Forest this year and the sample plots were not measured. The examination was made by G. R. Struble and J. E. Patterson in October. In his report, Patterson (30) advanced the following arguments for discontinuance of the sample plot method of survey as applied to the Sequoia.

> "Due to the extremely rough topography and interrupted continuity of timber stands, infestations are seldom uniform over even single watersheds and usually present great diversity in character and amount on larger areas. Under these conditions, sample plots of conventional size are largely inadequate as a yardstick for measuring insect losses on any one or any group of infestations areas. In future surveys of this Forest it is proposed that some other method of wider scope be employed."

As a result of this decision, the survey method adopted in 1942 consisted of a tally of insect-killed and abandoned trees along road strips of measured length; these road strip data were supplemented by visual counts of similar trees which could be seen in viewing of the areas from vantage points. Accessible trees were examined and measured. In this way it was possible to get a better idea of the distribution and character of the current infestation than from limited sample plots. The overall appraisal of conditions in the Forest for this year was summed up by Patterson.

> "Increased losses were evident on the southern part of the Forest whereas opposite conditions prevailed throughout the central and in general northern sections. Wherever increased losses occurred, ponderosa and sugar pines were both affected. The type of tree

"selected in the 1942 attacks ran largely to individuals with vigorous crown, indicating infestations in the aggressive stage. Pronounced top-killing occurred during the year in the northern section of the Forest. This type of injury was most prevalent in the ponderosa-sugar pine stands surrounding the Whitaker Forest where single trees were found infested with no evidence of grouping, although attacks were widespread. Engraver beetles were responsible for this injury.

		Annual Loss in Pines			
		1941		1942	
Name of Unit	Acreage	Trees	Volume	Trees	Volume
Whitaker	30,000	120	60,000	80	45,000
Woodward Creek	14,000	90	40,000	60	30,000
Mineral King	10,000	30	25,000	no estimate	
Camp Wishon	13,000	20	18,000	110	100,000
Camp Nelson	20,000	30	20,000	250	200,000
Tule River	30,000	150	60,000	200	80,000
Kern River	32,000	200	100,000	275	128,000
Totals	149,000	640	323,000	975	583,000 "

1943

A reconnaissance survey of the Forest was made in September by J. E. Patterson and J. M. Miller using the same methods as in 1942 in arriving at estimates.

"Generally low endemic conditions have prevailed throughout the Forest for the past three years. This condition was not greatly changed in the Kings River and Tule River area. However, the increase was not sufficient to indicate impending epidemic conditions."

In Patterson's report (31) the reporting units were changed to include watersheds in the lower Kern River and acreages of the former units were revised to conform to the methods of coverage adopted in 1942.

		Annual Loss in Pines			
		1942		1943	
Name of Unit	Acreage	Trees	Volume	Trees	Volume
Millwood	25,000	160	350,000	230	460,000
Bear Trap	20,000	130	140,000	180	215,000
Wishon	12,000	110	100,000	90	120,000
Nelson	16,000	250	200,000	200	160,000
Parker	12,000	300	360,000	160	180,000
Starvation	15,000	360	390,000	200	225,000
Peppermint	30,000	300	240,000	280	210,000
Johnsondale	20,000	90	75,000	110	90,000
Bull Run	15,000	60	30,000	70	35,000
Totals	165,000	1,760	1,885,000	1,520	1,695,000

1944

A reconnaissance survey late in the season by J. E. Patterson and G. R. Struble encountered such poor visibility because of storms that a report by the Berkeley laboratory was considered inadvisable for this year. The Annual Report (Engstrom) summarized the Rangers' reports:

> "In general, insect conditions on this Forest indicate a normal or slightly below normal population. However, mention should be made of the unusual loss of Digger pine along the Kern River Flats which is attributed to Ips and flatheads."

1945

For this year the survey of the Berkeley laboratory consisted of a reconnaissance late in August by J. M. Miller (32) which included mainly the pine areas of the Tule River and Kings River Districts. The following conditions in so far as trends were evident up to September 1 were pointed out in the report for this season.

> "The general run of 1945 losses in the commercial pine types were estimated to be less than 10 trees per section or 15 board feet per acre. This applies to all of the areas that were viewed with the exception of a zone just south of the Burnt Corral Burn in the Kings River District."

Conditions around the Burnt Corral Burn, which covered 5,000 acres on September 22, 1943, were attributed to the spread of infestation from fire-injured trees. It was estimated that there were between 500 and 1,000 1945 summer brood trees within and around the burned area. Some of this infestation appeared in small groups of 3 to 5 trees as far as three miles away from the perimeter of the burn. The infestation in the surrounding area, however, did not seem to be very aggressive and was not expected to develop much further.

At the request of Don Lewis an examination was made of several small experimental plots in the Kings River District which were thinned in 1944. It was found that Ips confusus had attacked some leave trees where the thinning had been done in pole-sized stands during the summer. In contrast, a plot in small saplings which had been thinned during the fall period showed no damage.

The needleminer area at Mineral King was examined for the first time in several years and it was found that both the needleminer and mountain pine beetle infestations had disappeared. Apparently there had been no serious attacks in this lodgepole area since 1940, and the trees were found to be recovering from the effects of the old defoliations.

II. THE MORE IMPORTANT FOREST INSECTS FOUND IN THE SEQUOIA N. F.

The preceding chronological summary lacks meaning unless given enough interpretation to appraise the significance of the insect infestations that have been noted in the past, and to formulate some ideas of what may be expected from them in future years. For this reason the following comments are included to explain the behavior of certain insect species which have shown a capacity for destroying timber stands in the Sequoia areas.

1. Defoliators.

So far defoliators have not invaded commercially valuable timber, but it is significant that a defoliator was the first insect species reported from the Sequoia. The history of the two needleminer epidemics in the Little Kern basin and at Mineral King throws some light upon the expected periodicity of these outbreaks and the effect of this type of defoliation upon Jeffrey and lodgepole pines.

a. The Jeffrey pine needleminer (Recurvaria sp.)

The identity of this species has not yet been determined by the taxonomists. In 1917 mature larvae and pupae in the needles were collected at Grey Meadow by Miller and sent to the National Museum. Adult moths, reared from this material, were at first determined by Dr. Heinrich, specialist in Lepidopters, as Recurvaria milleri Busck; but after further study the determination was changed to Recurvaria sp. Little is known about the life history of this species except that in the Little Kern area, mature larvae are found in the needles where they pupate in June and July and the moths emerge in late July and August. Whether there is a two-year life cycle, as is the case with the lodgepole species, or a one-year life cycle, has not been determined.

No one has estimated how long the epidemic infestation of this insect had been in progress in the Little Kern Basin before it was brought to notice by Dana's report in 1909. Obviously it had been going on for some years prior to that time. The examinations in 1910 indicated that many trees were then suffering from the effects of repeated severe defoliations. In 1915 Supervisor Lyons concluded that it had been at work for many years. However, the infestation seems to have started to die down about 1915 and was very light when Hopping and Miller visited the area in 1917. The absence of any subsequent reports indicates that the insect has not caused noticeable damage in the Little Kern area or elsewhere for the past 25 years.

The sample plot study by Wynne and Lyons shows that this type of defoliation on Jeffrey pines takes effect slowly and the trees are gradually weakened. The visible effect is thinning of the crowns and die-back of twigs and limbs.

b. The Lodgepole pine needleminer (Recurvaria milleri Busck.)

Although no official determination has been made of the needleminer in lodgepole pine at Mineral King, it is identical in appearance and habits with the species Recurvaria milleri Busck. which has been intensively studied in the Tuolumne Meadows region of the Yosemite. One unusual feature of the seasonal history of this species is its two-year life cycle. The moths emerge from their pupal cases in the needles in July of the odd years, as was noted at Mineral King in 1923 and 1931. Eggs are laid at the base of the needles soon after emergence, the young larvae bore into the needles and after a short feeding period overwinter in the needles. The next season, which is the even year (1924 and 1932), the larvae continue feeding and there is no emergence or flight. Throughout the second fall and winter the larvae remain in the needles and during the summer of the second odd year they pupate, emerge and fly.

The epidemic condition in the isolated lodgepole type at Mineral King has reoccurred with considerable regularity. Observations of the abundance of the insect since 1923 and the measurements of growth ring suppression in cores from selected trees indicate that severe defoliations occurred during the periods of 1901-1907, 1913-1915, 1921-1926, 1929-1932 and 1938-1941. One explanation for the rapid decline of the infestation soon after it reaches the epidemic stage may be found in the abundance of insect parasites. In 1931 Forest Guard Freeborn sent in a large collection of infested needles which were kept in rearing at the Berkeley laboratory. Many chalcid parasites were reared from this material. It is significant that the needleminer subsided the next year and did not recover until 1938. Although no active infestation was found in the area in 1945, it is altogether possible that the needleminer is still present in the area and may again become epidemic.

After two or three consecutive severe defoliations by the needleminer, lodgepole trees show evident signs of distress. The crown becomes very thin, the growth is suppressed and die-back of twigs and limbs sets in. Extensive killing has occurred, however, only where the mountain pine beetle has invaded the area and attacked the defoliated trees. Survival of most of the trees in the Mineral King area can be accounted for by the fact that the beetle did not come into the area for many years and when it did appear in 1938 it was present in such small numbers that it failed to establish an aggressive infestation.

c. The Alder leaf beetle (Haltica bi-marginata)

Defoliation outbreaks by this beetle have occurred in camp ground and recreational areas at about 3 to 5 year intervals. When outbreaks occur, the adults and larvae skeletonize the leaves during the late summer, but the trees are not seriously set back because the defoliation takes place after seasonal growth has been completed. The outbreaks last only a year or two because of natural control. During one outbreak at Camp Nelson in

1938 reported by the survey, the insect became so abundant that it was something of a household pest in camp grounds and summer homes.

2. Bark beetles

Various species of bark beetles have caused serious loss of trees in both commercial and recreational forests. A number of species are involved which often work in combination when trees are killed. Their taxonomy and biology are well covered in published information and need no review here.

a. Western pine beetle (D. brevicomis) in ponderosa pine type.

This has been the most common bark beetle concerned with ponderosa pine losses in the pine areas of this Forest. When losses are endemic the western pine beetle alone may be the only insect attacking mature, slow growing or injured trees. But when epidemic conditions develop, two other insects are often found to be associated with it. These are the pine engraver (Ips confusus) and the pine flathead (Melanophila californica) which attack the tops of trees in advance of the western pine beetle. Ips is by far the most common species in this association and attacks vigorous trees. The flathead is much less common and is found only in slow growing or weakened trees. At times various combinations of all three species may be found and in addition the mountain pine beetle (D. monticolae) may make a secondary attack on ponderosa pine by filling in bark areas not occupied by the other insects.

The old reports indicate that a number of outbreaks of this type of bark beetle infestation occurred in different areas of the Sequoia from 1910 to 1915. Large group attacks were found near Hot Springs in 1910 (3) which were attributed to the western pine beetle-Ips combination. In 1913 Hopping (5) pointed out infestations above normal at Camp Nelson, Wishon, Redwood Meadow, Dry Creek and Kings Canyon. In addition to these areas, the Forest Supervisor in 1914 (8) reported heavy infestations in the Mill Creek Basin and McKenzie Ridge. These reports do not give a complete picture of conditions, but they present enough information to show that this was a period of more than ordinary bark beetle activity. The comprehensive survey of 1917 (11) rated a number of these same areas as epidemic, but the amount of loss shown by the survey data does not indicate that conditions were of the spectacular character which appeared about 12 to 15 years later.

The period from 1929 to 1933 was marked by widespread aggressive infestations in which the intensity of the losses exceeded anything that has occurred on the Sequoia during the entire period from 1909 to 1945. This outbreak started with the top-killing of large groups of trees by Ips and the momentum of the epidemic built up as the western pine beetle increased its population in these top-killed trees. The surveys during this period did not estimate the overall accumulated loss in the ponderosa pine stands during this period, but it was obviously as much as 25 percent of the mature trees in areas that were hard hit.

In the long view the periodicity of the epidemics of the western pine beetle and associated species has been quite similar on the Sequoia to that on the Sierra National Forest, which was discussed by Miller, Struble and Hall (33) in a summary prepared in 1944. Beetle populations, as represented by pine losses, have remained at low levels over long periods. But at times sharp but short-lived epidemics have occurred with increased timber losses as much as ten times those that occurred during the long endemic periods. The interval between the wide-spread epidemics of 1913-1915 and 1929-1933 was about 15 years with some small local outbreaks occurring during the interval. About 12 years of relatively low loss levels have prevailed since the last general epidemic died down in 1933. A discussion of the probable causes of these fluctuations in pine beetle populations can be found in the Sierra Summary (33).

b. The Mountain pine beetle (D. monticolae) in sugar pine and lodgepole pine.

Most of the insect-caused loss in sugar pine has been due to this beetle. Losses have occurred each year without spectacular epidemics, but because of the large size of the trees that have been killed the volume has been formidable. The only record of conditions approaching the epidemic stage are found in the survey reports of 1939 and 1940 (28) which mention unusually high losses in sugar pine in the Ten Mile Creek area west of Hume.

In lodgepole pine the mountain pine beetle has been present in the meadow and stream sites where it has maintained small but persistent infestation centers in certain local areas over long periods, killing a group or two of trees each year. No large epidemic areas have been encountered, probably because of the interrupted distribution of lodgepole in the back country of the Sequoia.

c. The Jeffrey pine beetle (D. jeffreyi) in Jeffrey pine.

This beetle was first reported from the Little Kern area in 1910 (3) where it was active in the area infested by the needleminer. The course of this infestation was not followed through in subsequent reports, but there is reason to believe that the beetle infestation subsided as the needleminer died down.

In the western areas of the Forest, endemic infestations have always been found wherever any bodies of Jeffrey pine occurred. In the Woodward Creek area an aggressive infestation was reported in 1939 (27). This ran for about two years and then declined. On the whole, the Jeffrey pine beetle has been a minor factor in the pine losses.

d. The Pine engraver beetle (Ips confusus) in ponderosa pine.

Aside from its association with the western pine beetle already described, this engraver beetle has been a factor in itself in the killing of pine poles and saplings. Such killings have usually occurred sporadically and have frequently been associated with slash, windfalls and other conditions

which create a breeding ground for Ips populations. When the beetles leave the slash and attack standing green trees, widespread killings may occur but the momentum of the infestation usually dies down rather quickly in the green stands. Hopping (10) attributed the widespread killing of pine reproduction in Mill Creek Flat in 1910 to unburned slash left on adjacent logging operations.

During the season of 1945 experimental thinning plots in the Hume district encountered this type of trouble on a small scale (32).

e. The Fir engraver beetle (Scolytus ventralis) in white and red firs.

Losses in fir have been given little attention in observations and surveys, but in 1938 when these losses were measured on sample plots they exceeded those in pine. Most of this is caused by the fir engraver beetle which kills the tops, limbs and in many cases entire trees. The problem has been by-passed because of the low values which have been placed upon fir species and because no satisfactory control methods have yet been developed for this beetle.

III. SUGGESTIONS FOR AN INSECT CONTROL PROGRAM.

This review has attempted only to bring together information that has been scattered through a number of sources, and all that can be claimed is that it tells only part of the story of forest insect activities in this Forest during the past 35 years. Only the more accessible pine areas have been covered by observations and surveys. What the insects have been doing in parts of the back country is mainly a blank in the entomological record; but enough evidence has been brought to light in those areas that have been covered to show that the hazard of insect-caused losses is a real one and similar to that in other parts of pine regions where it is considered to be an important problem in forest protection and management.

The records also show, all too obviously, that the steps taken to deal with the insect problem have usually followed lines of expediency. Control work has been undertaken only where there was enough interest or pressure to stimulate some action or for experimental objectives. In the majority of the reported infestations, no control work was undertaken and the epidemics were allowed to run their course. As a result, losses in many of the pine areas have been heavier than should be tolerated under good forest management practices.

All of this adds up to an apparent lack of program and policy in dealing with the forest insect problem. There may be a sound excuse for this in that forest insect research and control in the Region has been focused in other National Forests where larger economic interests have been at stake. Also the highly varied forest types of the Sequoia, which are broken up into small irregular areas by rough topography, do not lend themselves to a broad application of forest insect surveys and control.

At the present time the adoption of an insect control program that will meet the peculiar needs of this Forest with its diversity of conditions in commercial, recreational and grazing areas seems desirable. To this end the following phases are suggested as the essential components of such a program.

1. A planned annual detection survey. Before this can be perfected, a study should be made of areas and forest types, permanent reporting units selected, and a rating of insect hazards made for each area.

2. Prevention of epidemic outbreaks through forest management practices.

Past records have shown that the most serious losses in the pine type have occurred during short epidemic periods, with long intervals of low endemic losses. Prevention of these outbreaks in accessible timber should be more profitable than control work after they have developed, or merely waiting for them to subside. The perfection of methods for such a program of prevention will require basic research as the sanitation-salvage method which has worked in eastside forests has not met the requirements of the westside pine types of the Sierras.

3. Direct control against threatening infestations in areas of high timber values and intensive use. Continued maintenance control is the only method now available for keeping bark beetle populations down in those areas where public interest demands that dead and dying trees be eliminated as far as possible. This type of control work will become more practical if improvement of techniques are finally perfected to reduce costs and increase effectiveness.

IV. REFERENCES

The following titles list the more important special reports and letters which are pertinent to the forest insect history of the Sequoia. In addition to the material in this list, the Annual Insect Control Reports of the Regional Forester have been quoted frequently. These Annual Reports, prepared by the Office of Forest Management, give a condensed summary of information submitted each year from the field by Forest Service personnel. To avoid repetition these Annual Reports are not included in the following list.

1. Hopkins, A. D. — Letter to S. T. Dana of the Forest Service, Washington, D. C., reporting on specimens of yellow pine needles submitted by Dana. This material contained the work of a needleminer. Sept. 1, 1909

2. Hopping, Ralph — Forest Insect Conditions in Ranger District Ten (Dunlap). November 1909

3. Miller, J. M. — Memo. to Forest Supervisor Patterson on an investigation of forest insect conditions in the Sequoia National Forest. July 29, 1910

4. Derby, W. F. — Forest Insect Conditions in the Springville District (including a description of the needleminer infestation in the Little Kern area). Nov. 1912

5. Hopping, Ralph — Forest Insect Conditions on the Kern and Sequoia National Forests. August 1913

6. Martin, Robt. R. — Report to the Forest Supervisor on Forest Insect Infestations and Control Work in the Greenhorn District. January 22, 1914

7. Hopping, Ralph — Report of bark beetle infestations in the Dry Creek area. August 1914

8. Cunningham, Frank — Letter to Regional Forester summarizing recent insect infestations and recommending a control program. November 1914

9. Lyons, George W. — Report on re-examination of needleminer study plot, Little Kern Area. September 2, 1915

10. Hopping, Ralph — Primary and secondary borers killing yellow, sugar and Jeffrey pines. March 2, 1916

11. Jaenicke, A. J. — Forest insect survey, Sequoia National Forest, Season of 1917. January 1, 1918

12. Hopping, Ralph — Kaweah insect control project. July 1918

13. Hopping, Ralph — Survey of Kings Canyon Area. January 1919

14. Cunningham, Frank — Letter to J. M. Miller reporting needleminer infestation in lodgepole pine at Mineral King. June 23, 1923

15. Cunningham, Frank — Letter to Regional Forester reporting serious insect infestations in Hume and Pinehurst areas. August 26, 1925

16. Stevenson, Ray — Memo. to Forest Supervisor reporting on examination of bark beetle infestations in Kings Canyon floor. June 18, 1930

17. Miller, J. M. — Bark beetle infestations, South Fork of Kings River Canyon. December 1930

18. Salman, K. A. — Forest Insect Conditions, Kings Canyon River District. December 1931

19. Struble, G. R. — Memo. to Forest Supervisor reporting on forest insect conditions in Camp Nelson and Camp Wishon areas. October 13, 1931

20. Miller, J. M. — Forest Insect Conditions, Sequoia National Forest, Season of 1931. March 8, 1932

21. Hopping, Guy — Forest Insect Conditions, Kings River Canyon. December 11, 1932

22. Brock, Wilkie — Letter to J. M. Miller reporting results and costs of bark beetle control work by State Unemployment Camp in Sequoia Lake Basin. May 4, 1933

23. Lewis, Don — Insect control, Camp Nelson project. Oct. 20, 1933

24. Patterson, J. E. — Forest Insect Conditions on Camp Nelson and Wishon areas. July 30, 1936

25. Patterson, J. E. — Survey of forest insect conditions in the Tule River District of the Sequoia N. F. Sept. 23, 1937

26. Carlson, S. T. — Forest insect survey, Sequoia N. F., Seasons of 1937 and 1938. October 22, 1938

27. Carlson, S. T. — Forest insect survey, Sequoia N. F., Season of 1939. December 19, 1939

28. DeLeon, Donald — Forest insect survey, Sequoia National Forest, 1940. December 20, 1940

29. Patterson, J. E. — Forest insect survey, Sequoia N. F., Season of 1941. January 12, 1942

30. Patterson, J. E. — Forest insect survey, Sequoia N. F., Season of 1942. March 2, 1943

31. Patterson, J. E. — Forest insect survey, Sequoia N. F., Season of 1943. March 14, 1944

32. Miller, J. M. — Forest insect survey, Sequoia N. F., Season of 1945. October 12, 1945

33. Miller, J. M., G. R. Struble and R. C. Hall — Forest insect control and investigations, Sierra National Forest, 1909-1943. June 8, 1944.